⇒ Thermodynamics :-

1). IDEAL GAS EQuations :-

$$\boxed{PV = mRT}$$

[abs] P = Pascals R = kJ/kgK
V = m^3
m = kg T = K [abs]

2) $\boxed{mR = n\bar{R}}$

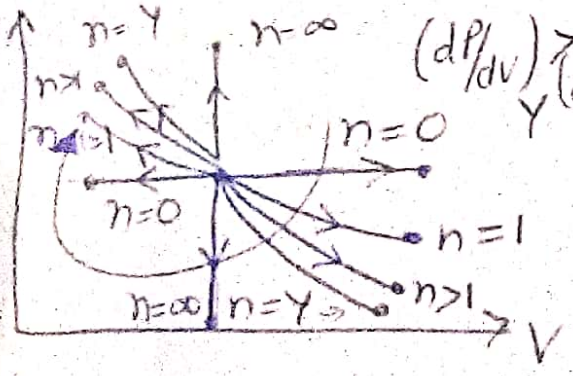
n = kmoles
$\bar{R}$ = 8.3140 kJ/kmole K

3) $\boxed{M = \frac{m\,(kg)}{n\,(kmole)}}$ & $\boxed{R = \frac{\bar{R}}{M}}$

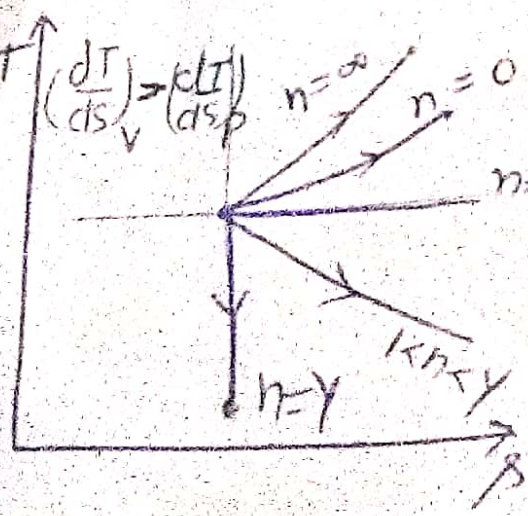
3). $\boxed{0°C = 273.15\,K}$

4). $\boxed{P + f = C + 2}$

5). $\frac{°C}{5} = \frac{°f - 32}{9} = \frac{K - 273.15}{5}$

6). 

$\left(\frac{dP}{dV}\right)_Y > \left(\frac{dP}{dV}\right)_T$

7). 

$\left(\frac{dT}{ds}\right)_V > \left(\frac{dT}{ds}\right)_P$

8). first law of Thermodynamics

a). for a Cycle :-

$$\boxed{\oint đQ = \oint đW}$$

IR Reversible / Reversible.

b). for a process :-

$$\boxed{đQ = dE + đW}$$

for Any System & Any process.

c). कौनसा eqn कहाँ लगता है :-

$đQ = dE + đW$ ⇒ Any process, Any Sys.

$đQ = đU + đW$ ⇒ Any process, Closed sys

$đQ = dU + PdV$ ⇒ Reversible, Closed sys

$đQ = TdS$ ⇒ Reversible process.

$TdS = dU + PdV$ ⇒ Rev / Irreversible (Closed) both

$TdS = dH - VdP$ ⇒ Rev / Irr. both (Closed)

9). Rajnikant eqn :-

$$\boxed{\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{Y-1}{Y}} = \left(\frac{V_1}{V_2}\right)^{Y-1}}$$

for $PV^Y = C$.

Air

$C_v = \frac{R}{Y-1} = 1.005$ kJ/kgK

$C_p = \frac{RY}{Y-1} = 0.718$ kJ/kgK

$C_p - C_v = R = 0.287$ kJ/kgK

C_p / C_v = Cons = Y

10). S.F.E.E :-

$$\dot{m}[h_1 + P.E_1 + K.E_1] + [\dot{Q}] = \dot{m}[h_2 + P.E_2 + K.E_2] + \dot{W}_{c.v}$$

or

$$\boxed{\dot{m}\left[h_1 + \frac{C_1^2}{2000} + \frac{gZ_1}{1000}\right] + \dot{Q} = \dot{m}\left[h_2 + \frac{C_2^2}{2000} + \frac{gZ_2}{1000}\right] + \dot{W}_{c.v}}$$

11). $\boxed{[COP]_{H.P} = [COP]_{Ref} + 1 = \frac{1}{\eta_{H.E}}}$

Cond^n :- Working all B/w Same Temp^r Limits

12). Clausius inequality :-

$$\boxed{\oint \frac{dQ}{T} \leq 0}$$

$\oint \frac{dQ}{T}$ < Irrevers.
= Rev.
> Impossible

13). Third Law of thermo dynamics :-

$$\boxed{\Delta S_{univ} \geq 0}$$

14). Second law of thermodyn.s [Law of degradation of energy] :-

$W = HGE$ & $Q = LGE$

$W \xrightarrow[\text{Converts}]{\text{fully}} Q$

But Reverse is not possible.

or Mathematically :-

$$\boxed{\eta_{H.E} < 100\%}$$

15). $[1-\eta_{comb.}] = [1-\eta_I][1-\eta_{II}]$

15). Entropy change of a system ds

a) $\int_i^f ds = C_v \ln\left[\frac{T_2}{T_1}\right] + R\ln\left[\frac{V_2}{V_1}\right]$

b) $\int_1^2 ds = C_p \ln\left[\frac{T_2}{T_1}\right] - R\ln\left[\frac{P_2}{P_1}\right]$

c) $\int_1^2 ds = C_p \ln\left[\frac{V_2}{V_1}\right] + C_v \ln\left[\frac{P_2}{P_1}\right]$

16). Slopes :- of T-S curve :-

$$\boxed{\left(\frac{dT}{ds}\right)_p = \frac{T}{C_p}, \quad \left(\frac{dT}{ds}\right)_v = \frac{T}{C_v}, \quad \left(\frac{dh}{dT}\right)_p = C_p, \quad \left(\frac{du}{dT}\right)_v = C_v}$$

$\left(\frac{dh}{ds}\right)_p = T$ (Mollier chart)

17). Availability & IRReversibility

A.E = Maximum Amount of work

$\boxed{A.E = Q_1 - T_0 \Delta S}$ → U.A.E

Loss of A.E = ↑ in U.A.E = $Q_1 T_0 \left[\frac{T_2 - T_1}{T_1 T_2}\right]$ [Irreversibility]

[Losed System :-

$$\boxed{W_{max} = [U_i - U_f] - T_0[S_i - S_f]}$$

$$\boxed{W_{max\ obtainable\ work} = [U_i - U_f] - T_0[S_i - S_f] - P_0 \Delta V}$$

Gib's Helmholtz f^n :- (Closed)

$$\boxed{F = U - TS}$$

OPEN SYSTEM :-

$W_{max} = W_{max\ obtainable\ work}$

$= [H_i - H_f] - T_0[S_i - S_f]$

Gib's f^n :-

$$\boxed{G = H - TS}$$

18 :-

ϕ [Availaibility f^ns.] :-

Closed	open
$\boxed{\phi_c = U - T_0 S - P_0 V}$	$\boxed{\phi_0 = h - T_0 S}$

$$\boxed{W_{max.obt.work} = \phi_1 - \phi_2}$$

19). Second Law Efficiency :-

$$\eta_{Second\ Law} = \frac{\eta_{Actual}}{\eta_{ideal}} = \frac{\eta_{Actual\ cycle}}{\eta_{carnot\ cycle}}$$

20). Vander-wall's Eeq^n :-

$$\boxed{\left[P + \frac{a}{v^2}\right][v - b] = RT}$$

21). Mixing :-

$$\boxed{C_{p\,mix} = \frac{m_1 C_{p_1} + m_2 C_{p_2} + m_3 C_{p_3} + \cdots}{m_1 + m_2 + m_3 + \cdots}}$$

$$h_{mix} = \frac{m_1 h_1 + m_2 h_2 + \cdots}{m_1 + m_2}$$

$$\boxed{R_{mix} = \frac{m_1 R_1 + m_2 R_2 + \cdots}{m_1 + m_2 + \cdots}}$$

$$x_1 = \frac{n_1}{n_1 + n_2} \text{ fraction.}$$

$$\boxed{P_1 = x_1 P_{mix}}$$

Solid $\xrightarrow[\text{Sublimation}]{\text{Directly}}$ Vapour

22). THERMODYNAMIC RELATION'S :-

$TdS = dU + PdV \rightarrow I^{st}$ T-d s eq^n

$TdS = dh - VdP \rightarrow 2^{nd}$ T-d s eq^n

$$TdS = C_v dT + T\left(\frac{\partial P}{\partial T}\right)_V dV$$

$$TdS = C_p dT - T\left(\frac{\partial V}{\partial T}\right)_P dP$$

$$dU = C_v dT + \left[T\left(\frac{\partial P}{\partial T}\right)_V - P\right] dV$$

$$dh = C_p dT - \left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right] dP$$

$$C_p - C_v = -T\left[\frac{\partial V}{\partial T}\right]_P^2 \left(\frac{\partial P}{\partial V}\right)_T = \frac{T v \beta^2}{K_T}$$

β = Volume expansivity $= \frac{1}{v}\left(\frac{\partial V}{\partial T}\right)_P$

K_T = Isothermal compress. $= \frac{1}{\text{Bulk mod}}$

$$= -\frac{1}{v}\left(\frac{\partial v}{\partial P}\right)_T$$

$$\mu_j = \left(\frac{dT}{dP}\right)_h = \frac{1}{C_p}\left[T\left(\frac{\partial v}{\partial T}\right)_P - v\right]$$

$\mu_j = 0$ for Ideal gas.

$$\left(\frac{dP}{dT}\right)_{sat.v} = \frac{S_g - S_f}{v_g - v_f} = \frac{h_{fg}}{T(v_{fg})} = \frac{P(L.H)}{T^2 R}$$

$\boxed{v_g >>> v_f}$

$v_f \approx 0$.

Maxwell's Relations :-

1). $\left(\frac{\partial T}{\partial v}\right)_s = -\left(\frac{\partial P}{\partial s}\right)_v$

2). $\left(\frac{\partial T}{\partial P}\right)_s = \left(\frac{\partial v}{\partial s}\right)_P$

3). $\left(\frac{\partial P}{\partial T}\right)_v = \left(\frac{\partial s}{\partial v}\right)_T$

4). $\left(\frac{\partial v}{\partial T}\right)_P = -\left(\frac{\partial s}{\partial P}\right)$

23) THERMODYNAMICS के कुछ CONCEPTS:-

Value of n:-

$n = 1.6666$ for Monoatomic
$n = 1.4$ for air/diatomic
$n = 1.3333$ for polyatomic.

24). CONTROL VOLUME WORK [OPEN SYS. WORK]:- $[W_{C.V}]$

↓

S.F.E.E $[\Delta PE = \Delta K.E = 0]$

↓

If $\dot{Q}$ = known

$$h_i + Q = h_e + W_{C.V}$$

If Q = unknown

$$W_{C.V} = \int_i^e -v\,dP$$

25). Q, U, H, S [Heat, I.E, ENTHALPY, ENTROPY]:-

$Q \Rightarrow$ [Heat]:- Always valid

$$Q_v = dU$$

$$Q_p = dH$$

U:- Internal Energy:-

$Q = C_v$ for {Solids & Liquids}

a) Liquids & Solids:-

$$dU = mC_{p/v}\,dT$$

b) Ideal gas:-

$$dU = mC_v\,dT$$

H [Enthalpy]:- $h = u + Pv$

a) Solid & liquids:- $[v = \text{const.}]$

$$dh = du + \cancel{fdv^0} + v\,dP$$

$$dh = C\,dT + v\,dP$$

b) Ideal gas $\Rightarrow C = C_p$

$$dh = C_p\,dT$$

S [Entropy]:-

a) Solid & Liquids:- $(v = C)$

$$S_2 - S_1 = m[C_p = C_v]\ln[T_2/T_1] + R\ln\left[\frac{V_2}{V_1}\right]^{\to 0}$$

b) Ideal gas:-

$$S_2 - S_1 = C_p \ln[T_2/T_1] - R\ln[P_2/P_1]$$
$$= C_v \ln(T_2/T_1) + R\ln(V_2/V_1)$$

c) Reservoir or phase change:-

$[T = \text{const}]$

$$S_2 - S_1 = \int \frac{dQ}{T} = \frac{Q}{T}$$

Atmospheric pressure conditions:-

$1\,atm = 1.01325\,bar = 10.3\,m$ of water column.

26) Triple point [WATER]

$T_{Tr.} = 0.01°C = 273.16K$

$P_{Tr.} = 611.7\,N/m^2$

27) Critical point [WATER]

$T_{cr} = 374°C$

$P_{cr} = 221.2\,bar$

$V_{cr} = 0.003175$ [DO TOUCH]

THERMODYNAMICS

1) $\frac{dU_{c.v}}{dt} = [\dot{m}_i h_i + \dot{Q}] - [\dot{m}_e \cdot h_e + \dot{W}]$

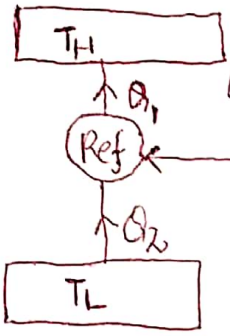
2) $\frac{dm_{c.v}}{dt} = \dot{m}_i - \dot{m}_e = \dot{m}_1 - \dot{m}_2$

$\gamma = 1.66667$ for Monatomic gas

$\gamma = 1.40$ for Diatomic gas / $\gamma_{air} = 1.4$

$\gamma = 1.33$ for Polyatomic

3)



$[COP]_{Ref} = \left[\frac{Q_2}{Q_1 - Q_2}\right] = \frac{\text{Desired effect}}{W_{net}}$

4) Heat Added/ Rejected at Const. pressure ($P=C$) :- [In Pure Substance]

then u/s :-

$dQ = dh - \cancel{vdp}^{\to 0}$

$\boxed{[Q_{1-2}] = [h_2 - h_1]}$ KJ/kg.

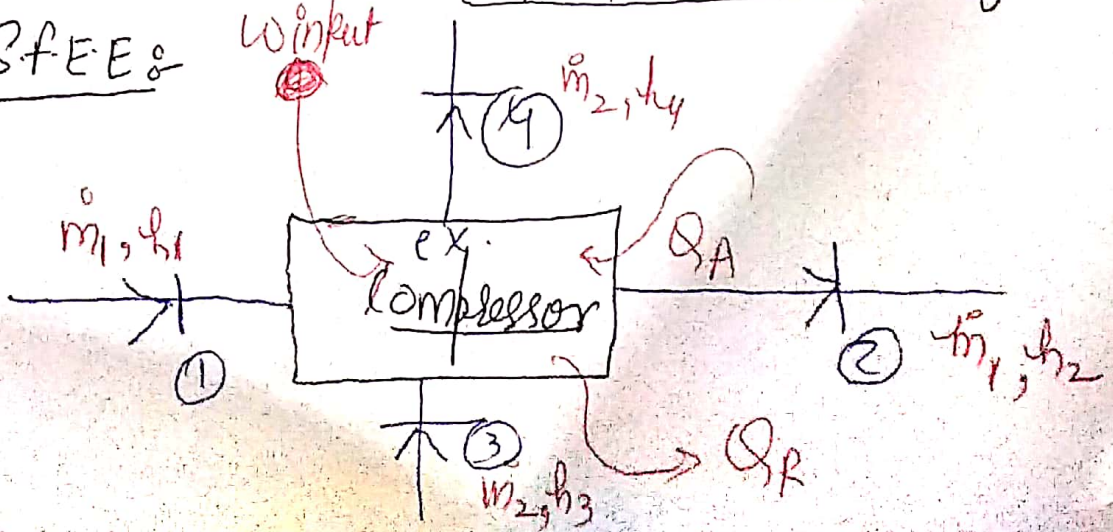
5) Heat Added / Rejected at const volume ($V=C$) :- [In pure Substance]

$dQ = dU + \cancel{Pdv}^{\to 0}$

$(dQ) = (dU)$

$\boxed{\Delta Q = Q_{1-2} = (U_2 - U_1)}$ KJ/kg.

6) S.F.E.E :-



$$\Delta S = \bar{R} n_1 \ln\left(\frac{}{x_1}\right) + n_2 \bar{R} \ln\left(\frac{}{}\right)$$

$$x = \frac{n}{n_1 + n_2}$$

$$E_{inlet} = E_{outlet}$$